

## **CO<sub>2</sub> on the International Space Station: An Operations Update**

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**PROBLEM STATEMENT:** We describe CO<sub>2</sub> symptoms that have been reported recently by crewmembers on the International Space Station and our continuing efforts to control CO<sub>2</sub> to lower levels than historically accepted.

**BACKGROUND:** Throughout the International Space Station (ISS) program, anecdotal reports have suggested that crewmembers develop CO<sub>2</sub>-related symptoms at lower CO<sub>2</sub> levels than would be expected terrestrially. Since 2010, operational limits have controlled the 24-hour average CO<sub>2</sub> to 4.0 mmHg, or below as driven by crew symptomatology. In recent years, largely due to increasing awareness by crew and ground team, there have been increased reports of crew symptoms. The aim of this presentation is to discuss recent observations and operational impacts to lower CO<sub>2</sub> levels on the ISS.

**CASE PRESENTATION:** Crewmembers are routinely asked about CO<sub>2</sub> symptoms in their weekly private medical conferences with their crew surgeons. In recent ISS expeditions, crewmembers have noted symptoms attributable to CO<sub>2</sub> starting at 2.3 mmHg. Between 2.3-2.7 mmHg, fatigue and full-headedness have been reported. Between 2.7-3.0 mmHg, there have been self-reports of procedure missed steps or procedures going long. Above 3.0-3.4 mmHg, headaches have been reported. A wide range of inter- and intra-individual variability in sensitivity to CO<sub>2</sub> have been noted.

**OPERATIONAL / CLINICAL RELEVANCE:** These preliminary data provide semi-quantitative ranges that have been used to inform a new operational limit of 3.0 mmHg as a compromise between systems capabilities and the recognition that there are human health and performance impacts at recent ISS CO<sub>2</sub> levels. Current evidence would suggest that an operational limit between 0.5 and 2.0 mmHg may maintain health and performance. Future work is needed to establish long-term ISS and future vehicle operational limits.